the substitution of cheaper or more effective methods. Unintelligent operation is truly false economy, and legislation should not be left to popular caprice, but be tempered and directed by sound scientific knowledge. Especially in such a delicately balanced operation as the scientific control of the natural waters is it necessary to know the facts. Where a small factor can determine the whole condition it is necessary to be familiar with all the details. If a limiting factor can be removed by a simple expedient it allows for expansion all along the line until the next lower factor replaces it. Perhaps this, in turn, may be eliminated with slight treatment, and by successive steps in biological technology can the capacity of the stream be greatly increased with the least expenditure of effort and money.

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PLEISTOCENE CLAYS AS A CHRONOMETER

The Swedish expedition now in America, led by Gerard DeGeer, has an ambitious program of proposed discovery. Following are quotations from his announcement:

. . . the undersigned described how he had, since 1878, worked out and utilized a method of determining by actual counting of certain seasonally distinct laminated clay layers, the chronology of the past 12,000 years, or the period that witnessed the evolution of man as well as of the whole fauna and flora of those parts of northern Europe and North America which during the Ice Age were barren deserts covered by extensive ice sheets, ...

By the new method of investigation it has now been shown to be possible to follow, step by step, how the large ice sheets receded and melted away, this being registered from the melting season of every year by the annual deposition of melting-water sediment, and especially of seasonally laminated clays.

The annual lamina from warmed years being thicker and from colder ones thinner, the chronological self-registering is at the same time a thermographical one. . . .

It will thereby no doubt be possible by a kind of primary triangulation to fix at a sufficient number of points the very years when they passed by the receding ice border. By interpolation between the figures thus obtained and by help of the already mapped moraine-lines, now to be accurately dated, the laws regulating the whole recession of the great ice-sheet can certainly be established and at the same time the rate by which the rideau was pulled away from the stage of life and the amount of time during which in every region of the northern part of the New World the plants and animals have had at their disposal for their immigration and settlement; the time required for the development of the soil and the vegetable mould, for the rivers and the lakes for their erosional work, and for the evolution of our prehistoric ancestor.

. . . . . .

Still, the most far reaching result of the whole investigation might be that so rapid and at the same time so widely distributed variations of the temperature of the air scarcely can be attributed to any other cause than variations in the amount of heat reaching the earth from the sun. . . .

If that program should be promptly carried out the pleasure from scientific discovery by future students will be reduced. Truly, a yardstick of geologic time is greatly desired. More desired than needed. We know that time is long, but how long? The most common question to the geologist is "how long ago?" But if we knew the exact number of years since the ice sheet disappeared from New York, whether 31,676 or 109,322 years it might satisfy some curiosity but would make little difference in human life and race evolution. For we know that geologic time is not to be measured by human standards, and when we deal in millions of years the number of the millions has little significance. The subject appeals to the imagination, especially of the non-geologic public, and if Mr. DeGeer can find out even a part of his program he will make interesting discovery and we applaud the effort. However, lest the public should be too greatly disappointed, it is well to realize some of the difficulties in the study.

The laminated glacial clays which are the subject of measurement were deposited in deep or quiet waters facing the receding front of

the waning glacier. Evidence is found in the excessive lime content, and in the occurrence of large ice-rafted bowlders imbedded in the fine clays. Also, the clays often rest directly on smooth glaciated rock, or on the glacial drift.

The Hudson-Champlain valley is the proper line for the study, and not southern Canada, for in the stretch from New York City to the foot of Lake Champlain, some 300 miles, we have the continuous record of the removal of the Quebec (Labradorian) glacier from the United States. The St. Lawrence valley clays are subsequent in time. Of the long period of ice advance we have no record, nor of its long standstill at the Long Island-Staten Island terminal moraine. The existing record is only that of the diminishing ice sheet and the recession of its border.

The laminated clays were derived largely from the glacial outwash, being the rockflour from the glacial mill. Partly they came from the land wash, by streams eroding the freshly uncovered glacial drift. At the time the clays were deposited the glaciated territory was much lower than to-day, having been depressed by the long-continued weight of the deep ice cap. With the lifting of the burden the land slowly rose. With the land rise the tidal currents and river flow in the shallowing waters swept away most of the clay deposits, or buried them along the sides of the valley under sand and gravel beds. The clays remaining and open to examination are only scattered and minor fragments of the original more or less continuous deposits. These remnants are found along the sides of the valleys; the bulk of the beds which occupied the prisms of the valleys has gone out to the sea.

In the Hudson we have no considerable beds south of Tappan Sea and Haverstraw Bay, although some clays in New Jersey may represent the early time. In the narrow stretch above Peekskill erosion has removed most of the clay, but we find good remnants in the wider valley of the Newburg district. Northward the next massive clays are at Kingston, with only small remnants beyond. In the Albany district and northward the sealevel waters were wide but shallow, and silt and sand plains laid down. In the deeper Champlain Valley massive clays were laid, not only in the broad basin but also in the valleys of tributary streams.

A similar history pertains to the Connecticut Valley and to every deep valley in New England and the maritime provinces having a deep estuary.

The lamination of the clays was produced by interrupted deposition, or variation in the rate of deposit. In the Lower Hudson and in the St. Lawrence the oceanic tides were a periodic factor. In the upper beds of any district the stream inwash of severe storms was an irregular factor. The periodic element on which emphasis is placed is the seasonal variation of the glacial outwash, due to differences of summer and winter melting. In non-tidal areas this may doubtless be discriminated from the superposed day and night variation; and from tidal variation in the open estuary districts. The irregular storm factor may not be a serious complication.

As a time record the clays must be regarded as overlapping, south to north, or as constituting a theoretical vertical column, the southern beds at the bottom of the column and the northern beds at the top. It becomes necessary, therefore, to correlate the laminæ; that is, to determine which particular series of laminæ in a southward section is identical in time with some lower laminæ in a northward section, so as to eliminate duplication. With the fragmentary character of the Hudson-Champlain beds it would seem impossible to identify horizons. And correlation of far separated localities with the indefinite moraine lines will be extremely difficult in either the Hudson-Champlain or the St. Lawrence valley.

DeGeer's estimate of Postglacial time as 20,000 years is certainly an underestimate for America. It should be understood that the ice sheet did not diminish steadily, or the front back away continuously. The ice margin had many oscillations, readvances and reretreats, each probably covering many thousands of years. In the Mississippi Valley between Cincinnati and Mackinac F. B. Taylor has mapped fifteen frontal moraines, each of which

is believed to represent readvance, or at least a long pause in the ice front. For these somewhat regular oscillations no secular cause appears adequate except the precision of the equinoxes, and Taylor figures the time, using the minimum of the precession periods, as 75,000 to 150,000 years. In New York we have many clear proofs of the great length of Glacial and Postglacial time. One of them refers to continental land uplift. Since the glacier passed off from New York the land at the north boundary has risen 740 feet, and that rise is all subsequent to the deposition of the Hudson-Champlain clays, though not to that of the clays of the St. Lawrence.

Any measurement of time by counting seasonal lamination of the Pleistocene clays will require conscientious study of many sections, with the same scrupulous care that Huntington gave to the counting of the growth rings in the California Big Trees.

The clay record, it should be repeated, is only the time while the latest ice sheet was passing off, and that time is only a fraction of glacial time, to say nothing of true Postglacial time.

It is apparent that the proposed study can not be done hurriedly, by reconnaissance and cursory methods. It is the work of a lifetime, and when done is little more than a guess. Possibly such study might develop criteria and methods that would give precision.

To attribute the long-period variation in world climate which produced the Pleistocene Glacial Period, and other vastly more ancient glaciation, to variability in solar radiation is the easiest way of explaining a difficulty. It has no scientific basis. We would better seek causes for climatic changes in the known geologic and atmospheric changes. For this Professor Chamberlin has blazed the path.

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GENERAL RESOLUTIONS OF THE PAN-PACIFIC SCIENTIFIC CONFERENCE[1]

1. FUTURE CONFERENCES

Since the present conference has been found highly inspiring and illuminating and an invaluable aid in defining the essential problems of the Pacific region, be it

Resolved that future similar conferences should be held at intervals of not over three years.

2. PERMANENT ORGANIZATION

The results of the First Pan-Pacific Conference have demonstrated the high value of meetings for the discussion of problems common to all countries whose interests lie wholly or in part within the Pacific area; and have shown that the problems relating to the welfare of Pacific peoples are too large and too complex to be solved satisfactorily except by sympathetic cooperation of individual institutions and governmental agencies. To develop a unity of interest and to make harmonious coordination practicable, it seems desirable that some permanent organization be established which may serve as the point of contact for representatives of various interests in the countries of the Pacific. Be it therefore

Resolved that the attention of the governor of Hawaii be called to the great opportunity afforded by an organization designed for the advancement of the common interests of the Pacific, including scientific research, and to the desirability of taking action which may lead to the development of such an organization vouched for and supported by the various Pacific countries.

3. INTERNATIONAL RESEARCH COUNCIL

Since this conference commends the organization of the International Research Council as a means toward coordinating research in science; be it

Resolved that it is the desire of this conference that any agency created for the guidance of scientific research and exploration in the Pacific region may be affiliated with the council and with the various national research councils of the nations of the Pacific.

4. SHIPS FOR EXPLORATION

The cost of scientific researches in the Pacific which involve the continuous use of a ship is prohibitive for most scientific institutions and individuals. The results of the *Challenger* and the *Wilkes* expeditions have

[1] Held at Honolulu, August 2 to 20, 1920.